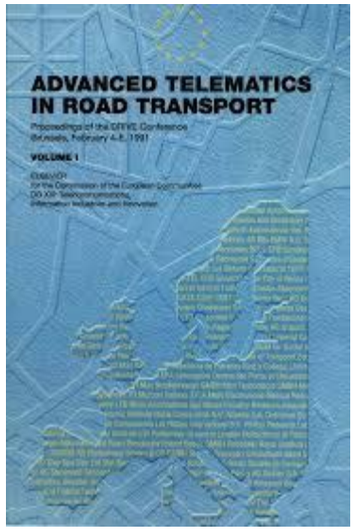
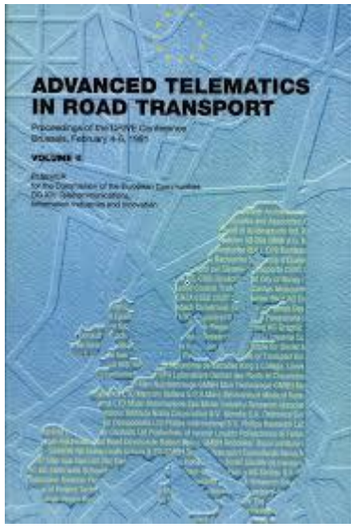
Are we ready for SAE Level 4 (on) Motorways?

Bart van Arem

How I met Frans…





AMSTERDAM GROUP

Get It In On The Road, Get It In the Vehicle.

TUDelft

Are we ready for SAE Level 4 (on) Motorways?
Frans op de Beek Retirement Seminar, Rotterdam 22nd June 2016

DAVI ONTHEROAD

Declaration of Amsterdam

Cooperation in the field of connected and automated driving

14-15 April 2016

TU Delft

Are we ready for SAE Level 4 (on) Motorways?
Frans op de Beek Retirement Seminar, Rotterdam 22nd June 2016

DAVI ONTHEROAD

High expectations rest on Automated Driving

Automated cars can improve traffic efficiency and safety

Netherlands to facilitate large scale testing of automated cars

Dealing with 50 shades of automation….

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	**High Automation**	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

Automated driving

Driver assistance/ Partial automation

Driver needs to be able to intervene at all times

Automated parking, autocruise

Conditional/ High automation

Vehicle in control in special conditions

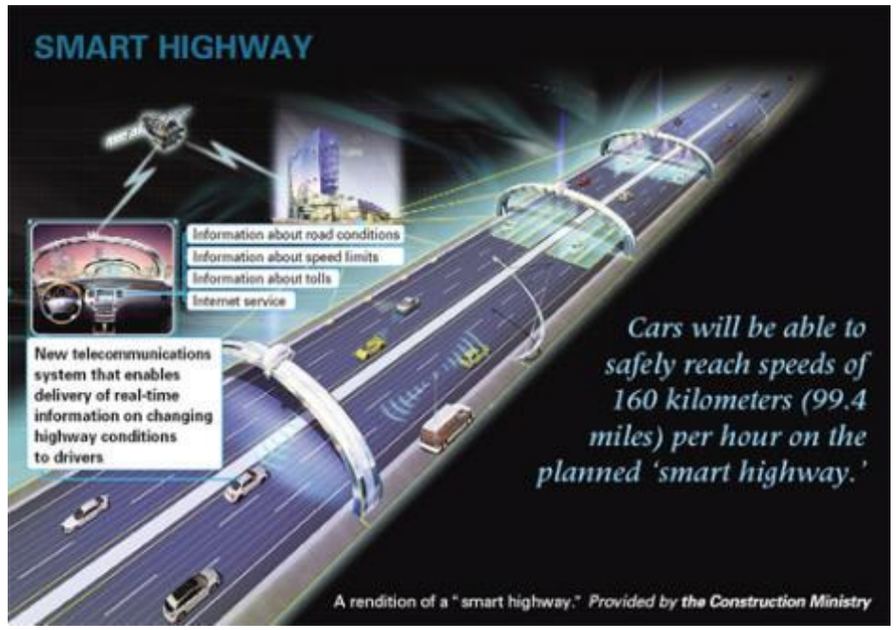
Taxibots, platooning, automated highways

Comfort, efficiency, safety, costs

Mode choice, location choice, urban and transport planning

What is it like to ‘drive’ in high automation?

What does a highly automated road look like?



Call in the experts!

TrafficQuest
CENTRE FOR EXPERTISE ON TRAFFIC MANAGEMENT

InfraQuest
COMPETENCE CENTRE FOR ROADS & STRUCTURES

TU Delft

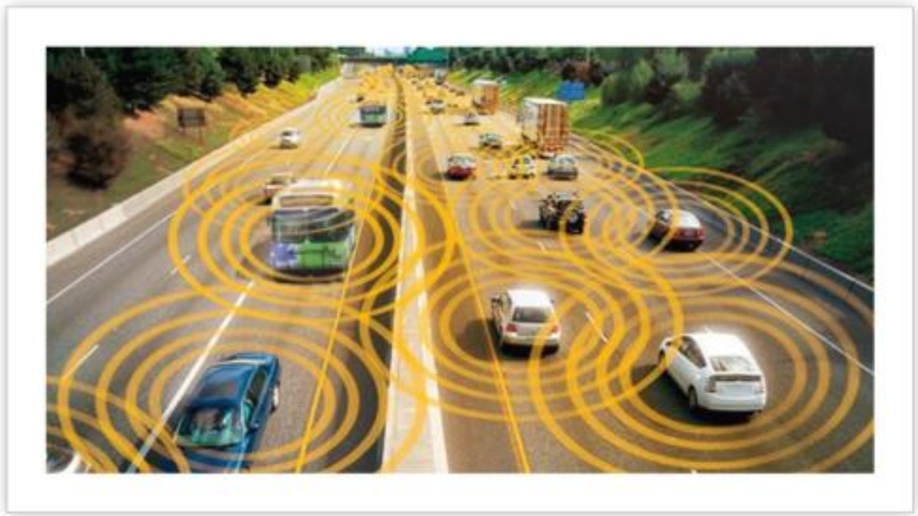
DAVI ONTHEROAD

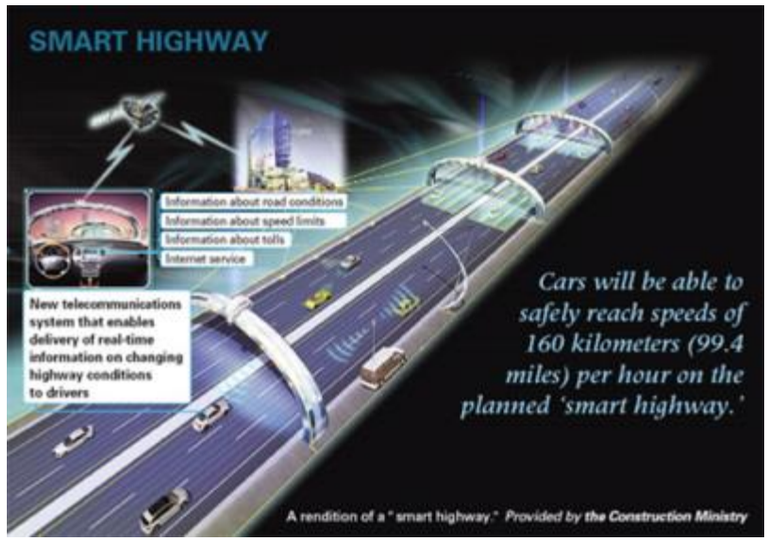
Infrastructure for automated driving

- Timing
  - Technological development
  - Penetration levels
  - Adaptions
  - Acceptance
  - Political readiness
  - Public opinion
  - Transition
  - Policy
- Society Trends
  - Sharification
  - Road billing
  - Electrification
  - Urbanization
  - Aging population
  - Public private partnerships
- User
  - Driver's behavior of automated and other vehicles
  - Psychology
  - Comfort and pleasure
  - Safety
- Legal
  - Infrastructure harmonization
  - Speed limits
  - Road signs
  - Police
  - International context
    - Left / right driving
    - EU
    - UK
  - Road operators
  - Responsibility / liability
  - Roadway certification
    - Standard rating for safety 5*- road*
- Costs, benefits
  - Environment
  - Social context
  - Economy
  - Safety
  - Better utilization of infra -> lower costs
- Traffic management systems
  - Which ones do we still need?
  - Under what circumstances?
  - Control scenarios
  - Road signage
  - Do we still need road signs?
- Digital infrastructure
  - Big data
  - Data transfers Contingency
  - Real time
  - Control
  - DATA Streams
  - From portals
  - Monitoring
  - From vehicles
  - Communication channels
  - Cyber security
  - Dynamic and costly
  - Who provides?
  - Who maintains?
- Surface quality, detect bad road surface
- Status monitoring
  - Sensors
- Vehicle positioning
- Using road markings
  - Whether and lightning conditions
  - Winter
  - Seasonal modes
- Vehicle mix
  - Charging batteries
  - Combination of electric and automated
  - Combination of electric and petrol
- Incident management
  - Large scale accidents
  - Fall back
    - Traffic management
    - Divert traffic
    - User behavior
    - Management of incapable vehicles
  - Automated / mixed
    - Level of mixture
- Transition
  - Mixed traffic
  - User safety
    - Accessibility of roads in rural areas
  - Urban areas
  - Zones
  - How do we speed up?
  - Mixed infrastructure
- Urban planning, spatial planning
  - Urban redesign
- Infrastructure
  - Dedicated vs.mixed
  - Private ownership (university campus, Schiphol, harbor, water authorities, etc)
- How do we design infrastructure from scratch
  - Forecasting and backcasting
  - Higher SAE level (4)
- Are there additional requirements to infrastructure?
  - Higher requirements? e.g. unevenness
  - Legacy system
  - Can we change geometry of roads in further future?
    - Do we still need viaducts at crossings?
    - How do we design intersections?
      - Flexible lanes, future proof, cheap and safe
      - Hard shoulder?
    - Length of weaving sections?
- Effect of automated driving on how the infrastructure is loaded
  - Do parameters for maintenance change?
  - Maintenance
    - Maintenance frequency
    - Maintenance costs
  - More loading
    - Lateral wander
      - Trucks
      - Cars
    - Skidding
  - Axel loads
    - Increase of road transport
      - Road transport cheaper -> Inverse modal shift
        - Trucks
        - Trains
        - Cargo
      - More trips?
  - Other loading
    - Order effect
    - More trucks
    - Vehicle dynamics
    - Structural safety
      - Bridges
      - Tunnels

Automated roads?

- Implication of changes in traffic load? Platoons, bridges, rutting?
- Automated driving under adverse roadway and weather conditions?
- Implications for traffic management? Opportunity or thread?
- eHorizon: automated driving cloud for real-time positioning, manoevering and safety?
- Level 4 certified roads?
- Geometric design, transition zones?
- Who is responsible?





Potential impacts on traffic

Non connected
Large penetration

Solve traffic jams by increased outflow

Prevent traffic jams by better stability

Better distribution of traffic over network

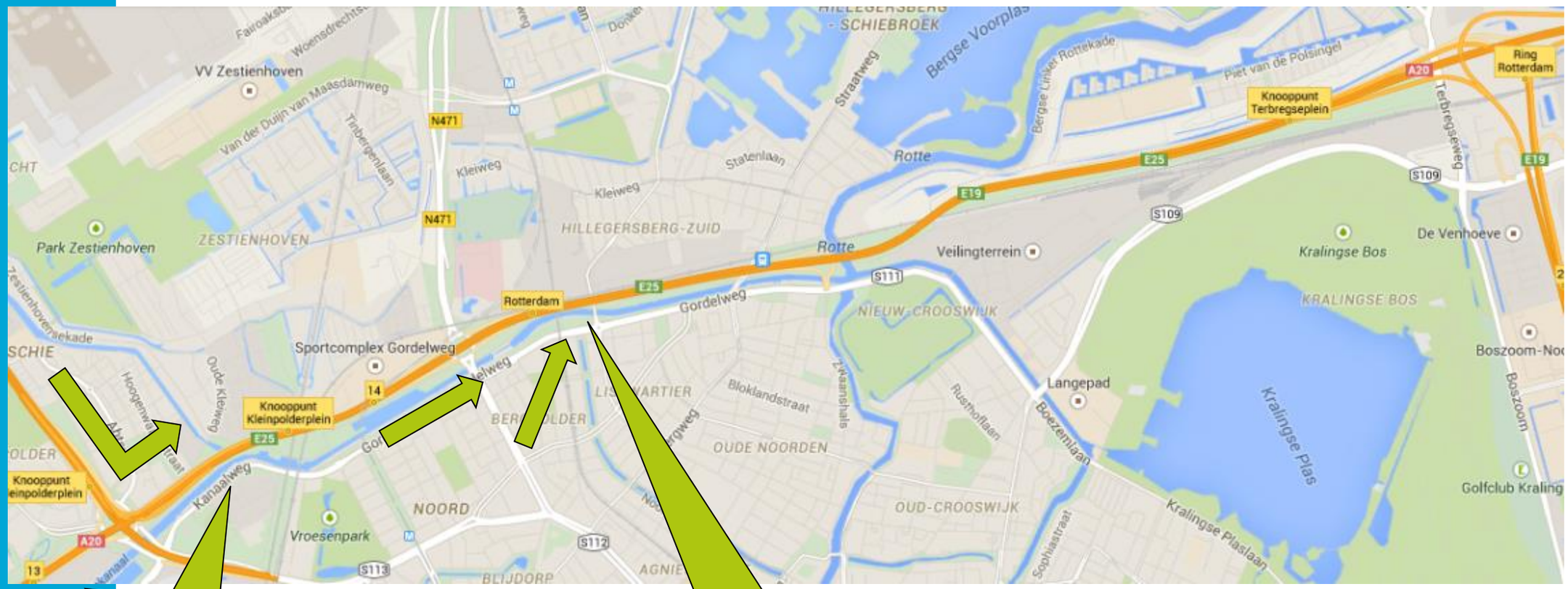
Decreased throughput by larger headways

Decreased stability by lack of anticipation

Less congestion delay

Increased risk of congestion

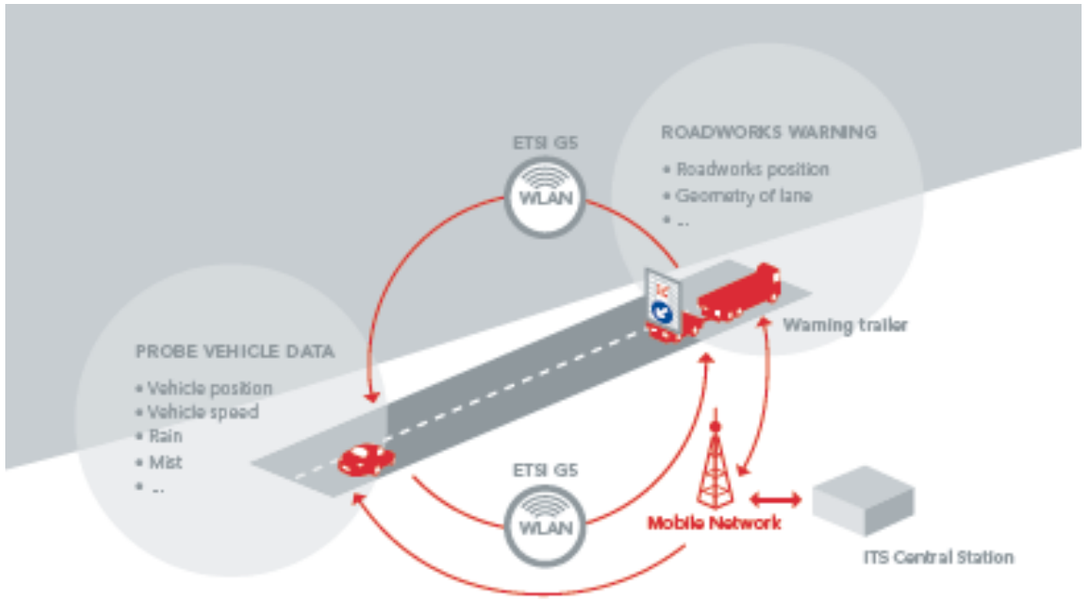
Imagine yourself an automated vehicle!

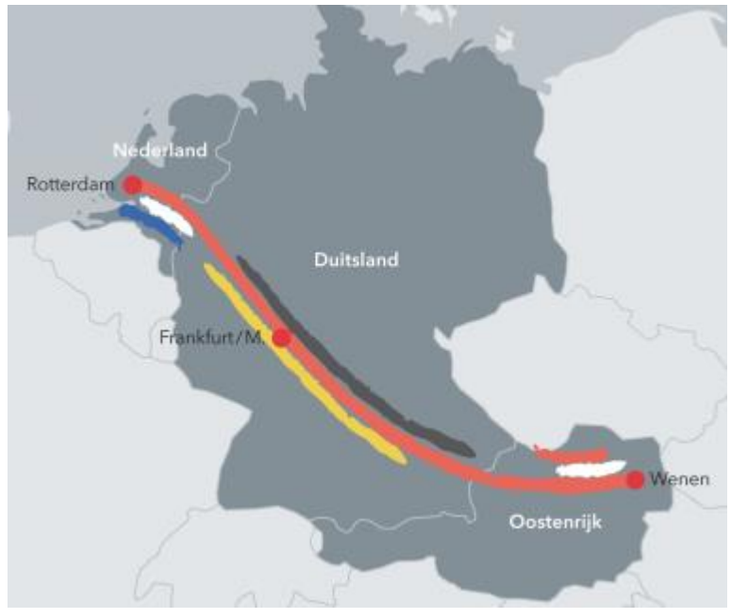


3+2 cross weaving

Short on-ramp

How can AVs relieve congestion here?





Cooperative
ITS Corridor
Joint deployment

V2V	I2V/V2I
Hazardous location warning	Road works warning
Slow vehicle warning	In-vehicle signage
Traffic Jam ahead warning	Signal phase and time
Stationary vehicle warning	Probe Vehicle Data
Emergency Brake light	
Emergency vehicle warning	
Motorcycle approaching indication	

(Very rough) Exploration using LMS

Automated Autonomous

5% capacity <u>decrease</u> on primary road network

	Index km travelled
Train	100.3
Car driver	99.8
Car passenger	99.7
Bus, tram, metro	100.2
Cycling	100.1
Walking	100.1
Total	99.98

Index congestion 115.7

Automated Cooperative

15% capacity increase primary road network
10% capacity increase secondary road network
10% decrease value of time commuting and business car trips

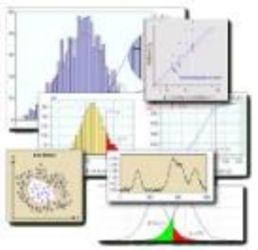
	Index km travelled
Train	98.8
Car driver	100.8
Car passenger	101.4
Bus, tram, metro	99.2
Cycling	99.3
Walking	99.4
Total	100.10

Index congestion 69.1

From demonstration to research and deployment!

Develope efficient and reliable technology

Collect, analyse and publish large scale real-world experience



Study spatial, transport and societal impacts

Regulations, type approval

Awareness, ambitions, expectations, reality checks

What we can learn from Frans